Future Computing Environment and Issues of Security

David B. Nelson, Ph.D., CISSP

Director

National Coordination Office for

Information Technology Research and Development

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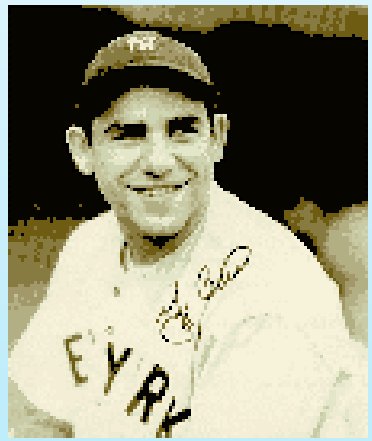
George Mason University

Looking Ahead Helps Us Prepare, However ...

“Predicting is tricky, especially about the future”

–Yogi Berra



Likely Characteristics of Future Computing Environment

- **Critical to the enterprise**
  - Agent for most business
  - More robust and self-regulating (autonomic computing)
- **Widely distributed**
  - "The network is the computer" - Scott McNealy
  - Use of middleware: Grid services, Web services, collaboration tools
  - Computing on demand using remote resources
- **Ubiquitous**
  - Always available by wireless and wired connections
  - Portable identity and workspace
  - Human-centric with improved collaboration, communication, and resource discovery tools
- **Heterogeneous**
  - Many different kinds of devices with different power and characteristics
  - Alternative technologies for organization/presentation of data

Likely Characteristics of Future Computing Environment

- **Extended beyond organizational boundaries**
  - Virtual organizations
  - Membership and trust issues
- **Dynamic**
  - Discovery and use of resources
  - Management and configuration issues
- **Mediated by middleware**
- **Challenging to maintain security**
  - Hard to determine what is inside vs. outside
  - Hard to determine appropriate usage/users for identity, authentication, authorization
  - Web Services will mean port 80 is used for "everything"
  - Increasing demands for privacy and anonymity
  - Need for role-based security
- **If we are very lucky, perhaps re-designed to be more intrinsically secure**

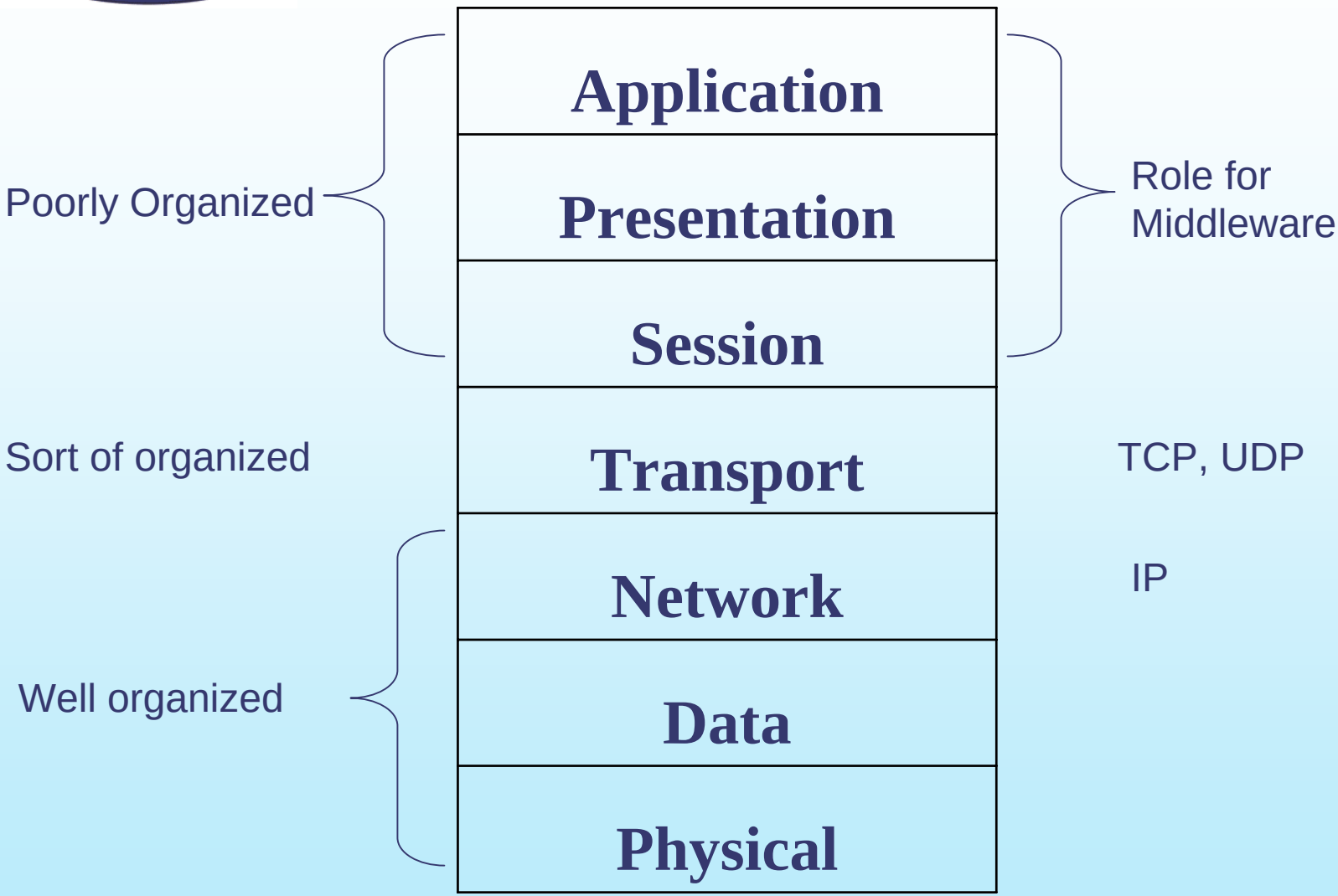
Security Concerns Are Also Evolving

- **Classic security concerns deal more with data**
  - Confidentiality (data only available to those authorized)
  - Availability (you can get it when you want it)
  - Integrity (data hasn't been changed)
- **Additional concerns deal more with people and transactions**
  - Trust (Who you are and what you are authorized to do)
  - Non-repudiation (You can't deny doing something you did)
  - Auditability (I can check what you did to the data)
  - Reliability (The system does what I want when I want it to)
  - Privacy (Within certain limits no one should know who I am or what I do)
  - Some of these were "solved" in stand-alone mainframe environment; much harder in networked environment

Security Challenges of Future Computing Environment

- How to accommodate vision of distributed large-scale collaborations, access to resources, eCommerce, without compromising security?
- How to accommodate dynamic computing environment within current framework of security risk management?
- How to evolve security practices and technologies to keep up with future computing environment?
- How to build security into architecture of future environment, including ability to withstand, identify, and respond to attacks?
- How to say “yes” rather than “no” to users and developers without compromising security?

Middleware Is Software That Helps Organize ISO Network Layers 5-7



ISO 7-layer Network Model

Grid Computing: Example of Distributed Computing Enabled by Middleware

- **Goal: Enable a geographically distributed community [of thousands] to perform sophisticated, computationally intensive analyses on Petabytes (10^{15} bytes) of data**
- **Organizations coordinating Grid tools and security**
  - Global Grid Forum www.ggf.org
  - Globus Project www.globus.org
- **Standards: Open Grid Services Architecture, Open Grid Services Infrastructure (uses Web services)**
- **Globus Toolkit™ centers around four key protocols**
  - *Security*: Grid Security Infrastructure (PKI, X.509 certificates, SSL, extensions for single sign-on and delegation)
  - *Resource Management*: Grid Resource Allocation Management
  - *Information Services*: Grid Resource Information Protocol
  - *Data Transfer*: Grid File Transfer Protocol (GridFTP)

Examples of Data Grid Projects

- **European Data Grid (EU)**
  - DG technologies & deployment in EU
- **GriPhyN (NSF)**
  - High Energy Physics, Investigation of "Virtual Data" concept
- **Particle Physics Data Grid (DOE Science)**
  - DG applications for HENP
- **Earth System Grid (DOE Science)**
  - DG technologies, climate applications
- **Information Power Grid (NASA)**
  - DG applications

Particle Physics Data Grid

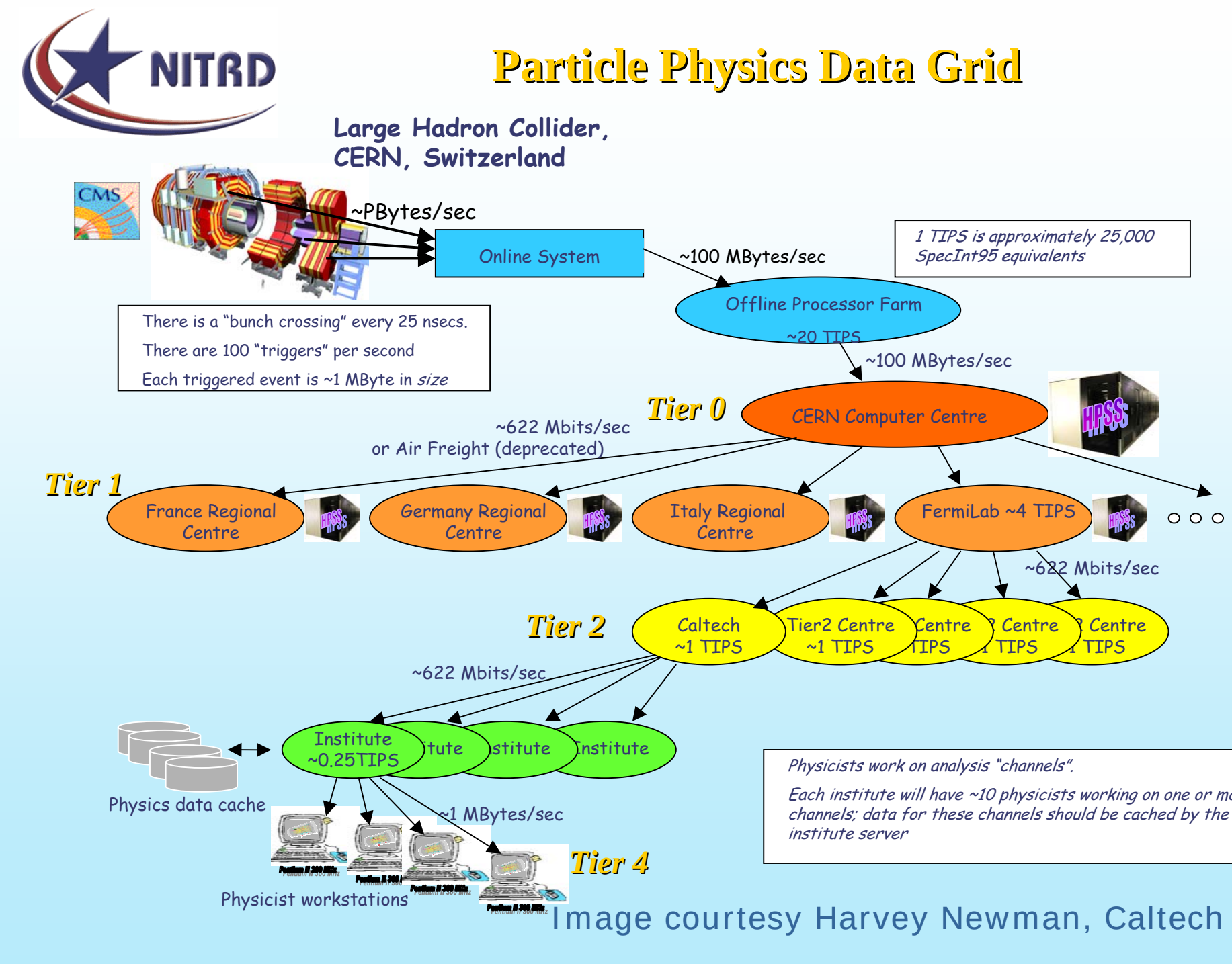
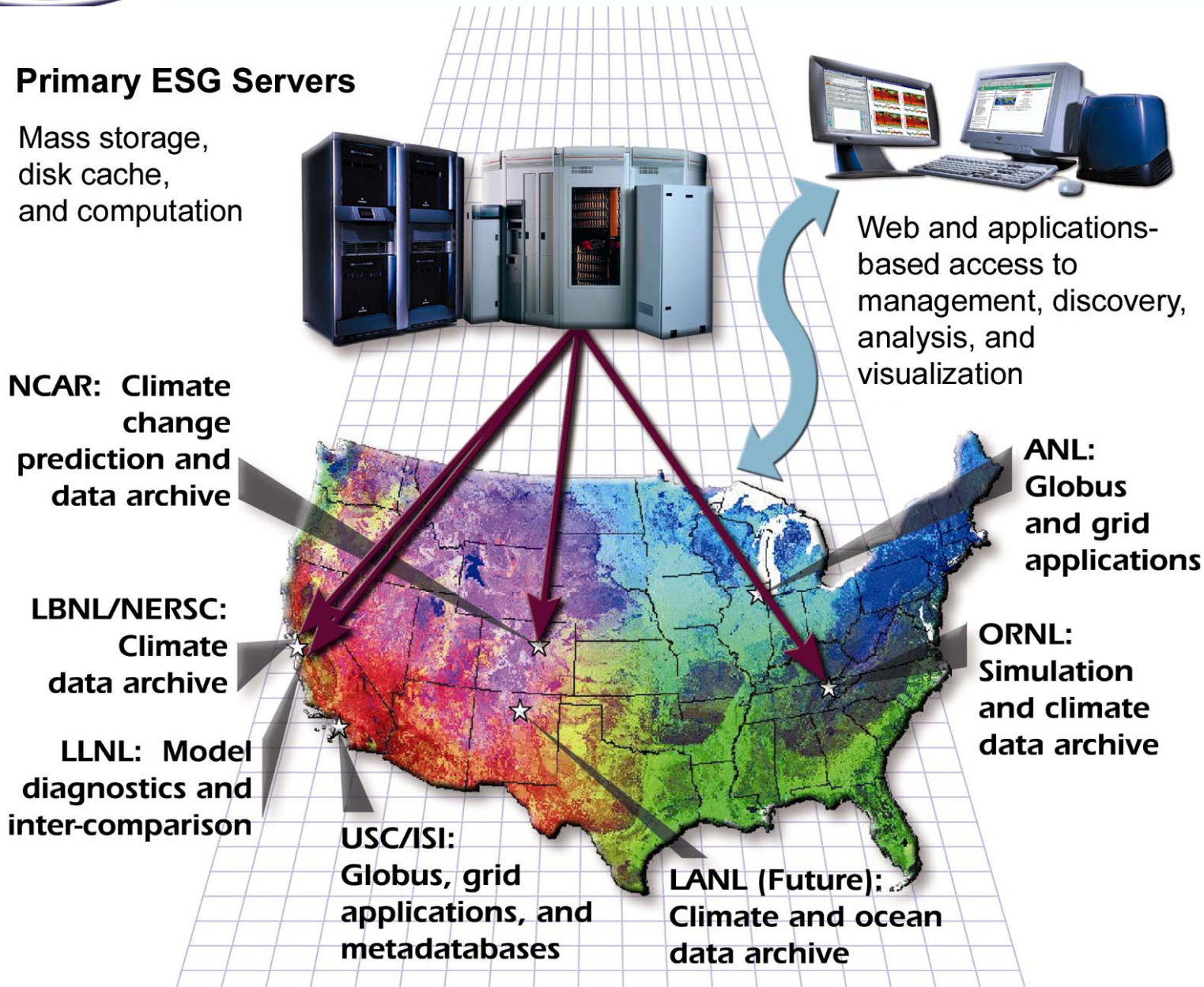


Image courtesy Harvey Newman, Caltech

Earth System Grid



Security Implications of Grid Computing

- **Need to allow access to trusted sources, but how do you determine trust in a dynamic community of thousands (or more) in different organizations?**
- **Need to allow Web services on port 80 (HTTP) or port 443 (SSL, HTTPS) through the firewall**
  - Application level firewalls
- **Companies such as IBM, HP, and Microsoft offer commercial grid software and services, but typically only for Intragrids (inside organizations) where security can be managed coherently**
- **The more interesting security issue is the virtual organization or Intergrid**
  - Unsolved problem, because current solutions create Federations of Enterprises based on pair-wise trust agreements; these don't scale

Security Implications of Grid Computing

- **Today Globus Toolkit uses Public Key Infrastructure for both authentication and authorization**
- **Some experts advocate using PKI only for authentication (based on a certificate authority)**
- **Use directory services for authorization (probably LDAP) with communication through Security Assertion Markup Language (SAML)**
  - Shibboleth is a reference implementation http://shibboleth.internet2.edu
- **SAML is a web-based language (over HTTP) that allows three kinds of messages:**
  - Attribute assertions
  - Authentication assertions
  - Authorization assertions
- **For some transactions we need to add privacy**
  - How to anonymize identity, attributes, actions, and personal data?
  - Being researched as part of the DARPA Total Information Awareness project

Why should we care about privacy?

- **History has shown that available information can be abused to persecute individuals with differing beliefs**
  - Nazi Germany
  - Stalinist Russia
  - Maoist China
  - Iraq under Hussein
- **Even in the US**
  - Exile of Nisei from coastal California in WW2
  - McCarthy anti-Communist hearings
  - CIA domestic spying (Church committee hearings of 1973)
- **Laws explicitly safeguard some information privacy**
  - Gramm-Leach-Bliley Act covers privacy of financial records
  - Health Insurance Portability and Accountability Act of 1996 (HIPAA) covers privacy of medical records
  - European Union Directive 95/46 covers protection of personal data

Example of Middleware: Web Services

- Architecture and program interfaces that enable application-to-application communication
- Run primarily on top of http (or https) web protocols
- Allow aggregation of functions provided by heterogeneous software modules, including legacy apps
- Allow changes to underlying components without manual reprogramming
- Allow seamless extension of functions and services

Web Services are Emerging Standards for eCommerce

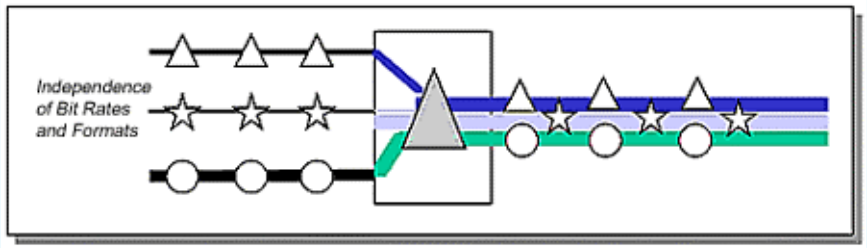
- XML (Extensible Markup Language) defines a universal way of representing any data; allows exchange of data between any applications regardless of operating system, language, hardware, user device
- SOAP (Simple Object Access Protocol) defines universal Web service requests using XML messages, making process integration simple
- WSDL (Web Services Definition Language) specifies information needed for integration among applications
- UDDI (Universal Description, Discovery, and Integration) is a Web service that allows users and applications to locate other Web services

Security in Web Services is Just Being Developed

- **HTTPS/SSL for secure point-to-point communication with known trusted parties, but**
  - no authorization, auditing, non-repudiation
  - not end-to-end, stops at HTTPS server
  - no digital signature verification through to the data base
- **WS-Security: message level security protocol**
  - persists end-to-end
  - interoperable with web services such as SOAP, SSL, Kerberos, PKI, SAML, etc.
  - http://www-106.ibm.com/developerworks/library/ws-secmap/
- **Managing trust issues is still a challenge**

Future of Network Technology*

- **Optical transmission - pushing the limits of fiber**
  - –Ultimate bandwidth of a fiber
  - –Wavelength division multiplexing
  - –Wavelength (λ) switching
  - –Fiber to the home – problems of economics (sunk cost) and technology (interconnects)



Merges *optical* traffic onto one common fiber
Allows high flexibility in expanding bandwidth
Reduces costly mux/demux function, reuses *existing* optical signals
Individual channels use original OAM&P

DWDM = Dense WDM

- **Optical switching - the chip of networking?**
  - Today it is done with mirrors
  - Need lower power optical switches
  - Would have substantial effect on computing also
- **Quality of Service vs. Over-provisioning**
  - QoS called for but hasn't emerged
  - Over-provisioning expensive but easy
  - λ switching can create circuits – a middle ground

*Thanks to George Strawn, NSF, for some of this material

Future of Network Technology*

- **End-to-end (e2e) high performance is hard to achieve (even with network head room)**
  - 50 Mb/sec. on 1 Gb/sec. Paths
- **Applications requiring e2e high performance are slow to emerge**
  - ftp as Grid killer-ap
  - We "forget" that Internet applications requiring low performance were slow to emerge, too!
  - High Definition Video?
- **How to build firewalls running at wire speed**
- **Wireless access everywhere--ad hoc nets**
  - Self organizing
  - Cheap devices
  - Mems-based sensors
  - Energy storage limitations – fuel cells?
  - Benefit from IPv6

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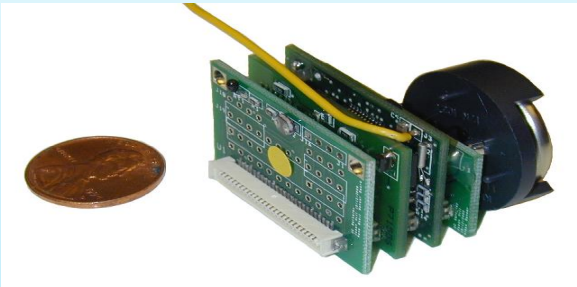
"Smart Dust"

- **UC Berkeley Project sponsored by DoD and Intel**
- **Near-Term goal: millimeter sized sensor and communication package**
  - RF, laser, modulated corner reflector
  - Temperature, humidity, pressure, light intensity, magnetic field, acceleration
- **Could be used for environmental monitoring or surveillance**
- **Experiment: air dropped swarm that spotted and tracked vehicles**
  - Magnetometer, self organizing rf network, Tiny OS



Business Models*

- **Peer-to-peer makes all clients into servers**
  - Kazaa model (major consumer of university bandwidth)
  - Groove Networks model
  - Logistical Computing and Internetworking model http://loci.cs.utk.edu/
- **Open standards and open source change the nature of competition**
- **Whither Intellectual Property?**
- **Disruptive technologies - tool of capitalist creative destruction (Where have all the mainframe makers gone?)**
- **Will networking fragment the firm by reducing transaction costs?**
  - Ronald Coates – theory of transaction costs, Nobel Prize 1991

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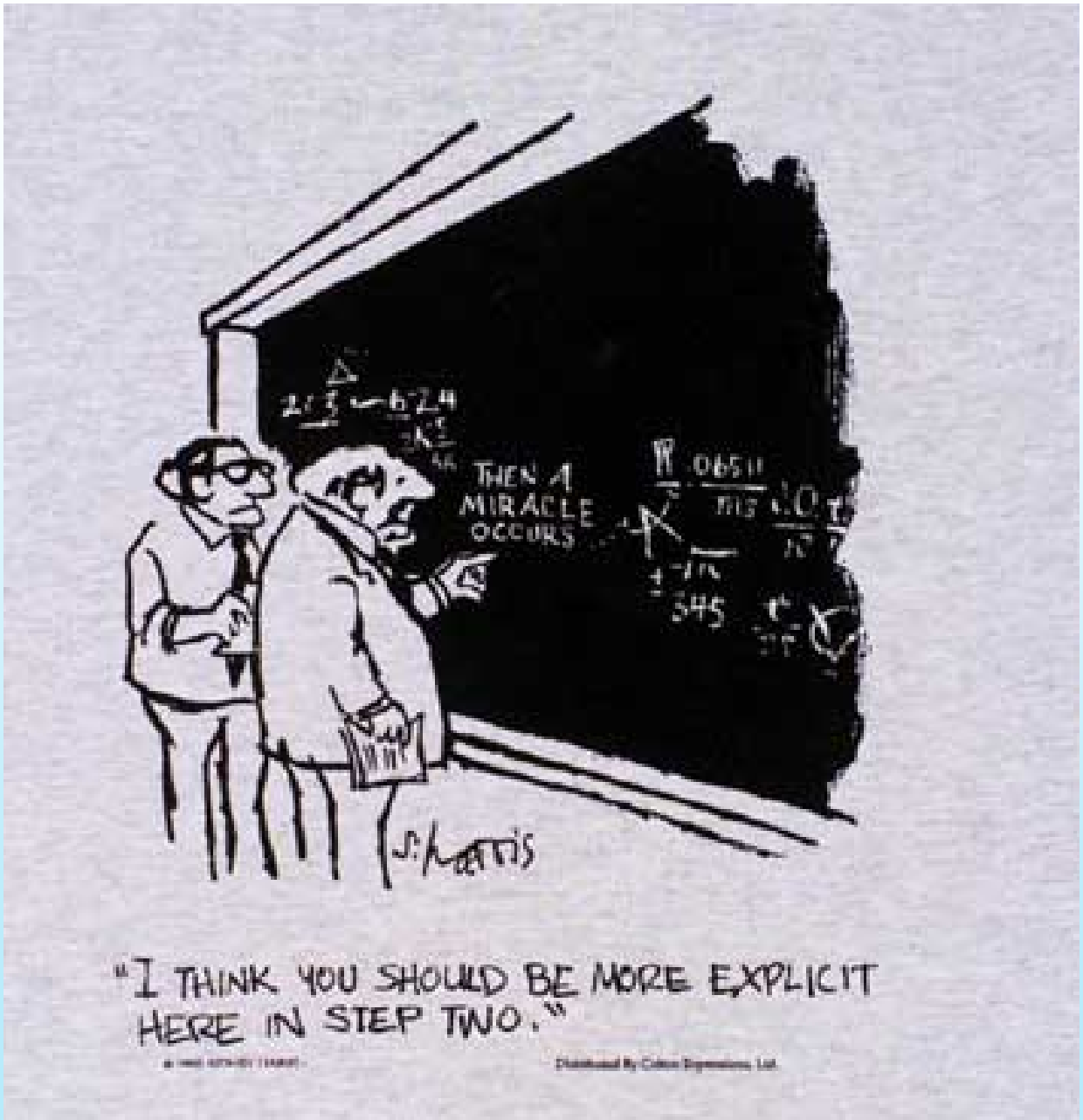
Emerging Issue of Role-Based Security

- **Role based security: Each of us assumes different roles with different security requirement. One individual may act as:**
  - Manager signing timecards or authorizing procurement
  - Researcher working on data with foreign collaborators
  - Individual buying books from Amazon.com at lunch hour
- **How to handle these different roles using common equipment (PC, network)?**
- **Alternative is separate networks and equipment for each role that requires a different levels of security or access - cumbersome and impractical**

Summary

- Future computing environment is likely to be more enterprise-critical, distributed, and dynamic than today
- Maintaining security will be challenging
- Probably new inventions will be needed (architecture, protocols, software, etc.)

Then a Miracle Occurs



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nco@itrd.gov

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